

The Currency Component of Cross-Border Stock and Bond Investments

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Background

The recent trend toward greater international diversification of stock and bond portfolios shows no signs of letting up in the years ahead as investors increasingly invest cross-border in search of higher risk-adjusted returns and as globalization of the world's security markets continues to simplify the process of investing cross-border. This trend has spawned a considerable amount of research directed toward improving our understanding of how cross-border investing affects portfolio risk and return.

Not surprisingly, increased cross-border investment activity has brought with it a greater interest in the role that currencies play in shaping portfolio risk and return. In particular, many of the recent studies on cross-border investing have been concerned with the currency component of portfolio risk and return. Researchers have addressed such issues as whether currency risks should be hedged and whether currencies should be treated as a separate asset class.

The common theme emerging from this research is that the role currencies play in affecting portfolio risk and return is complex, depending on the interaction of a number of variables. In addition, the nature of this interaction is, itself,

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subject to change over time. Consequently, it is difficult to derive meaningful generalizations about exactly how the currency component of cross-border investments should best be managed.

The purpose of this study is twofold: (1) to summarize the theoretical relationship between currency risk and return and overall portfolio risk and return and (2) to measure empirically the effects that currencies have had on portfolio risk and return over the past five years.

This study looks at both stock and bond portfolios and at portfolios for which currency exposures are hedged as well as those for which no hedges are used. It examines optimal hedge ratios and reviews recent trends in key variables that determine portfolio risk and return. Empirical portfolio results are presented using stock, bond and currency returns from ten countries.

Currency-Unhedged Returns

The return that an investor earns on a cross-border investment is termed the base-currency return. The base-currency return on a currency-unhedged cross-border investment depends on the return on the investment, measured in terms of the cross-border currency and referred to as the *local market return*, and on the return that is tied to any change in the currency exchange rate that occurs between the time and investment is made and the time it is sold or valued, referred to as the *currency return*. (Appendix A contains a more detailed, algebraic treatment of the risk and return on cross-border portfolios.)

Annualized geometric average local market returns for stocks and bonds in ten major countries for the period 1991-1995 are presented in Table 1. Data used in this study are total return data, taking into account dividend income (stocks) and interest income (bonds) as well as changes in capital value. Stock return data were obtained from Morgan Stanley Capital International while bond return data

were constructed using data obtained from the International Monetary Fund.

With the exception of Japanese stocks, all total return values were positive. Annualized stock returns ranged from -0.08 percent to 20.34 percent while bond returns ranged from 9.01 percent to 17.19 percent. Local-market stock returns averaged 11.62 percent while bond returns averaged 12.85 percent.

Local market risk, defined as the annualized standard deviation of quarterly returns, a measure of return volatility, ranged from 8.7 percent to 22.7 percent for stocks and from 5.9 percent to 12.9 percent for bonds. Local market return volatility averaged 14.3 percent and 7.62 percent for stocks and bonds respectively.

Currency risk and return pairs are presented in Table 2. Currency returns are geometric average returns; currency risk is defined as the annualized standard deviation of quarterly currency returns.

Two points should be noted. First, in terms of their absolute value, paired returns ranged from as low as .04 percent to as high as 12.6 percent. The absolute value of returns averaged 4.07 percent per year for all 90 currency pairs. This suggests that, on average, currency returns had a meaningful impact on overall cross-border investment returns. Currency pair return volatilities averaged 11.92 percent, suggesting that, on a stand-alone basis, currency volatility lies between bond volatility and stock volatility.

Second, a positive currency return with respect to one country implies a negative return with respect to the other country. In some cases, however, the absolute values of the paired returns differ. For example, the Japanese yen appreciated 6.34 percent relative to the Australian dollar while the Australian dollar declined 6.25 percent relative to the Japanese yen. When this occurs, the gain to one country always exceeds the loss to the other country, a result that is sometimes referred to as Seigel's paradox. (See Seigel, 1972.)

Currency-unhedged risk and return for cross-border stock investment pairs are presented in Table 3. Annualized returns ranged from -3.10 percent to 29.91 percent, averaging 11.63 percent. Return volatilities ranged from 8.1 percent to 28.0 percent, averaging 17.99 percent.

Table 1 Local Market Risk and Return by Country*

(1991 Q1 - 1995 Q4, in %)

Country	Stocks		Bonds	
	Return	Risk	Return	Risk
Australia	14.18	12.6	17.19	9.8
Canada	9.03	8.7	13.31	6.8
France	8.55	14.2	12.96	6.9
Germany	8.76	15.4	12.07	6.2
Italy	9.40	22.7	17.16	12.9
Japan	-0.08	20.6	10.04	6.5
Netherlands	16.52	12.0	12.31	5.9
Switzerland	20.34	14.9	9.01	6.1
U.K.	14.01	13.1	13.73	7.1
U.S.	15.44	9.1	10.67	8.0
Mean	11.62	14.3	12.85	7.6

* Returns are annualized quarterly geometric average returns; risk is the annualized standard deviation of quarterly returns.

Table 2 Currency Risk and Return*

(1991 Q1 - 1995 Q4, in %)

Base Currency	C r o s s B o r d e r C u r r e n c y									
	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
Australia		-2.44 8.0	1.60 16.8	1.67 17.9	-6.06 16.1	6.34 18.3	1.71 18.1	2.91 19.4	-3.53 13.8	0.80 7.8
Canada	2.45 8.2		4.07 14.7	4.13 15.8	-3.65 14.8	8.84 14.7	4.17 15.9	5.39 17.1	-1.10 12.3	3.26 4.7
France	-1.60 16.3	-4.03 14.7		0.06 2.5	-7.64 10.7	4.72 12.8	0.10 2.6	1.30 4.7	-5.12 7.1	-0.80 14.0
Germany	-1.66 17.3	-4.09 15.7	-0.06 2.4		-7.70 11.7	4.66 12.6	0.04 0.8	1.24 4.4	-5.18 8.3	-0.87 14.7
Italy	6.16 16.5	3.68 15.3	7.78 11.5	7.85 12.6		12.60 17.0	7.89 12.8	9.11 13.4	2.57 8.1	6.97 15.1
Japan	-6.25 18.3	-8.65 14.8	-4.67 12.6	-4.60 12.3	-12.21 16.1		-4.57 12.3	-3.38 13.8	-9.72 13.7	-5.46 13.2
Netherlands	-1.70 17.4	-4.13 15.7	-0.10 2.6	-0.04 0.8	-7.74 11.8	4.62 12.6		1.20 4.1	-5.22 8.4	-0.91 14.7
Switzerland	-2.89 18.6	-5.31 16.9	-1.30 4.6	-1.24 4.4	-8.91 11.8	3.41 13.8	-1.20 4.1		-6.40 9.3	-2.10 16.2
U.K.	3.56 13.7	1.10 12.7	5.18 7.8	5.25 9.0	-2.55 7.9	9.96 13.9	5.29 9.2	6.50 10.6		4.37 12.6
U.S.	-0.80 7.8	-3.23 4.6	0.80 13.7	0.87 14.5	-6.85 14.1	5.54 13.2	0.91 14.6	2.11 15.8	-4.32 12.0	

* Returns are annualized quarterly geometric average returns; risk, defined as the annualized standard deviation of quarterly returns, appears beneath each currency return value. A\$ = Australian dollar, C\$ = Canadian dollar, FF = French franc, DM = German mark, IL = Italian lira, JY = Japanese yen, DG = Dutch guilder, SF = Swiss franc, BP = British pound and US\$ = U.S. dollar.

Table 3 Currency-Unhedged Stock Risk and Return*

(1991 Q1 - 1995 Q4, in %)

Base Currency	C r o s s B o r d e r S t o c k									
	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
Australia		6.53 13.8	10.19 16.0	10.47 14.7	3.20 23.6	6.27 23.5	18.29 13.9	23.40 16.3	10.36 15.4	16.27 13.6
Canada	16.72 13.0		12.71 14.0	12.99 13.7	5.67 23.1	8.76 23.4	20.86 11.2	26.00 12.8	12.88 13.4	18.33 8.1
France	12.53 23.9	4.91 19.7		8.83 15.0	1.59 27.7	4.65 23.9	16.62 10.8	21.71 14.4	8.72 17.0	14.61 17.9
Germany	12.46 24.7	4.84 20.9	8.48 14.8		1.52 28.0	4.58 24.0	16.56 11.8	21.64 15.6	8.65 18.0	14.54 18.5
Italy	20.55 23.7	12.79 19.8	16.50 18.7	16.78 17.2		12.52 24.6	24.73 14.9	29.91 16.2	16.67 17.6	22.68 19.2
Japan	7.71 23.9	0.18 18.2	3.78 16.2	4.06 17.8	-3.10 23.4		11.76 14.8	16.79 17.0	3.95 20.1	9.77 17.4
Netherlands	12.42 24.8	4.80 21.0	8.44 14.9	8.72 15.7	1.48 28.0	4.54 24.1		21.60 15.6	8.61 17.9	14.50 18.5
Switzerland	11.19 25.8	3.59 21.6	7.22 16.4	7.50 17.0	0.28 28.0	3.33 23.7	15.27 12.7		7.39 18.3	13.26 19.9
U.K.	17.87 20.0	10.15 17.0	13.84 13.1	14.12 11.8	6.79 24.5	9.89 24.3	22.02 9.3	27.17 13.3		19.98 16.6
U.S.	13.36 14.5	5.72 11.5	9.37 13.9	9.65 13.5	2.39 21.6	5.46 21.8	17.46 11.0	22.55 11.9	9.54 14.7	

* Returns are annualized quarterly geometric average returns; risk, defined as the annualized standard deviation of quarterly returns, appears beneath each currency return value.

Currency-unhedged risk and return for cross-border bond investment pairs are presented in Table 4. Annualized returns ranged from 3.67 percent to 23.61 percent, averaging 12.86 percent. Return volatilities ranged from 6.4 percent to 20.4 percent, averaging 14.12 percent.

Currency-unhedged return pairs exhibited considerable variation, with average bond returns being about one percentage point higher than average stock returns and with average bond risk being roughly four percentage points lower than average stock risk. While bond return volatility can be expected to be less than stock volatility, the fact that bond returns outperformed stock returns reflects the fact that a global cyclical decline in bond yields occurred in the past five-year period. Historically, over longer time frames, stock returns have exceeded bond returns, and are likely to do so in the future.

Currency-Hedged Returns

Currency exposure can be hedged using forward contracts. When a currency hedge is put in place, the investor locks in the exchange rate at which the cross-border currency will be converted back to the base currency on a preset future date.

When this forward exchange rate is different from the current spot exchange rate, the investor either incurs a cost or receives a benefit on the hedge, depending on whether the forward rate is less than or greater than the spot rate. The rate of return associated with this cost or benefit is referred to as the forward premium.

The forward premium can be viewed as a measure of the rate of return on the currency-hedged component of a cross-border investment (see Appendix A.) In accord with covered interest parity principles, a positive forward premium occurs when the cross-border interest rate is less than the base currency interest rate; the opposite gives rise to a negative forward premium.

Forward premium pairs are presented in Table 5. Forward premiums tend to be smaller than their currency return counterparts presented in Table 2 above. In absolute value terms, forward premiums pairs averaged 2.28 percent per year (compared to 4.07 percent for currency return pairs) while their annualized standard deviations averaged 0.92 percent (compared to 11.92 percent for currency returns.)

Currency-hedged risk and return for cross-border stock investment pairs are presented in Table 6. Annualized returns ranged from 0.97 percent to 25.68 percent, averaging 11.62 percent. Return volatilities ranged from 8.4 percent to 22.6 percent, averaging 14.26 percent.

Currency-hedged risk and return for cross-border bond investment pairs are presented in Table 7. Annualized returns ranged from 6.83 percent to 21.24 percent, averaging 12.85 percent. Return volatilities ranged from 6.0 percent to 19.5 percent, averaging 7.73 percent.

As with currency-unhedged return pairs, currency-hedged return pairs exhibited considerable variation, with average bond returns being about one percentage point higher than average stock returns. Average bond risk, however, was roughly 6.5 percentage points lower than average stock risk. This suggests that the risk reduction effects of currency hedging are greater for bonds than for stocks.

Table 4 Currency-Unhedged Bond Risk and Return*

(1991 Q1 - 1995 Q4, in %)

Base Currency	C r o s s B o r d e r B o n d									
	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
Australia		10.79 12.1	14.62 17.4	13.79 18.6	10.84 16.9	16.54 20.4	14.07 17.9	11.99 19.8	10.08 16.2	11.49 13.4
Canada	19.75 10.1		17.16 14.3	16.33 15.4	13.36 15.6	19.10 16.1	16.61 14.9	14.52 16.8	12.59 14.8	14.02 8.3
France	15.53 17.5	9.15 16.1		12.13 6.3	9.20 18.3	14.88 13.4	12.42 5.7	10.35 7.6	8.44 11.0	9.85 13.5
Germany	15.46 18.6	9.08 17.1	12.90 7.6		9.13 18.9	14.81 13.1	12.35 5.8	10.28 7.6	8.37 11.9	9.78 14.2
Italy	23.61 16.4	17.11 16.1	21.00 13.0	20.15 14.4		22.95 19.2	20.45 13.4	18.33 16.6	16.39 11.5	17.82 15.4
Japan	10.68 20.4	4.38 17.1	8.15 13.9	7.33 13.1	4.42 20.0		7.61 13.9	5.56 14.8	3.67 16.9	5.07 14.6
Netherlands	15.42 18.8	9.04 17.2	12.86 7.8	12.03 6.4	9.09 19.0	14.77 13.2		10.24 17.5	8.33 12.0	9.74 14.2
Switzerland	14.18 19.9	7.82 18.2	11.62 8.7	10.79 8.1	7.87 19.0	13.53 14.7	11.08 7.5		7.11 12.7	8.52 15.6
U.K.	20.91 14.2	14.45 14.1	18.31 9.8	17.47 11.4	14.50 15.8	20.25 15.1	17.76 10.6	15.66 13.4		15.16 13.3
U.S.	16.36 10.5	9.97 8.3	13.79 13.1	12.96 13.9	10.02 14.4	15.71 15.0	13.25 13.4	11.17 15.5	9.26 14.3	

* Returns are annualized quarterly geometric average returns; risk, defined as the annualized standard deviation of quarterly returns, appears beneath each currency return value.

Table 5 Forward Premium Risk and Return*

(1991 Q1 - 1995 Q4, in %)

Base Currency	C r o s s B o r d e r C u r r e n c y									
	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
Australia		0.28 0.5	-1.37 1.4	-0.25 1.2	-3.84 1.4	3.35 0.9	-0.07 1.2	1.19 1.1	-0.90 0.8	2.30 0.6
Canada	-0.28 0.5		-1.65 1.1	-0.52 1.1	-4.11 1.1	3.07 0.9	-0.35 1.0	0.92 1.0	-1.17 0.8	2.02 0.6
France	1.38 1.4	1.65 1.1		1.13 0.7	-2.48 0.4	4.73 1.1	1.30 0.7	2.57 0.9	0.47 1.1	3.68 1.5
Germany	0.25 1.2	0.52 1.1	-1.12 0.7		-3.60 0.9	3.60 0.6	0.18 0.1	1.44 0.4	-0.65 0.8	2.55 1.4
Italy	3.88 1.4	4.16 1.1	2.50 0.4	3.63 0.9		7.26 1.3	3.81 0.9	5.08 1.1	2.97 1.2	6.20 1.4
Japan	-3.32 0.9	-3.05 0.9	-4.68 1.0	-3.56 0.6	-7.13 1.2		-3.39 0.6	-2.14 0.5	-4.21 0.6	-1.04 1.2
Netherlands	0.07 1.2	0.35 1.0	-1.30 0.7	-0.18 0.1	-3.77 0.9	3.42 0.6		1.26 0.3	-0.83 0.7	2.37 1.3
Switzerland	-1.19 1.1	-0.91 1.0	-2.55 0.9	-1.43 0.4	-5.02 1.0	2.15 0.5	-1.26 0.3		-2.08 0.6	1.10 1.3
U.K.	0.90 0.8	1.18 0.8	-0.47 1.1	0.65 0.8	-2.95 1.2	4.25 0.6	0.83 0.7	2.09 0.6		3.20 1.2
U.S.	-2.29 0.6	-2.01 0.6	-3.65 1.5	-2.53 1.3	-6.11 1.4	1.04 1.2	-2.36 1.3	-1.10 1.3	-3.18 1.2	

* Returns are annualized quarterly geometric average returns; risk, defined as the annualized standard deviation of quarterly returns, appears beneath each currency return value.

Table 6 Currency-Hedged Stock Risk and Return*

(1991 Q1 - 1995 Q4, in %)

C r o s s B o r d e r S t o c k										
Base Currency	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
Australia		9.31 8.6	7.15 14.1	8.51 15.4	5.47 21.8	3.27 20.9	16.44 12.1	21.59 15.1	13.08 12.9	17.83 9.3
Canada	13.90 12.6		6.87 14.2	8.23 15.5	5.19 22.0	2.99 21.0	16.16 12.2	21.30 15.2	12.80 13.0	17.54 9.3
France	15.60 12.6	10.71 8.7		9.91 15.6	6.86 22.6	4.66 21.1	17.87 12.2	23.04 15.4	14.51 13.2	19.27 9.0
Germany	14.44 12.5	9.56 8.5	7.40 14.1		5.72 22.2	3.52 20.9	16.70 12.0	21.85 15.0	13.34 12.9	18.09 8.7
Italy	18.20 12.6	13.28 8.6	11.10 14.2	12.47 15.6		7.18 21.4	20.48 12.3	25.68 15.4	17.09 13.3	21.88 9.1
Japan	10.74 12.5	5.91 8.4	3.77 14.1	5.12 15.3	2.11 21.8		12.99 11.9	18.09 14.9	9.66 12.8	14.36 8.9
Netherlands	14.25 12.5	9.38 8.5	7.22 14.1	8.58 15.3	5.54 22.1	3.34 20.8		21.66 15.0	13.16 12.9	17.90 8.8
Switzerland	12.95 12.4	8.09 8.4	5.94 14.0	7.30 15.2	4.27 21.8	2.07 20.7	15.21 11.9		11.86 12.8	16.59 8.8
U.K.	15.11 12.6	10.23 8.4	8.07 14.3	9.43 15.4	6.38 21.9	4.18 20.9	17.38 12.1	22.54 15.2		18.87 9.2
U.S.	11.81 12.3	6.97 8.6	4.82 13.8	6.18 15.3	3.15 21.6	0.97 20.9	14.06 12.0	19.18 14.9	10.72 12.8	

* Returns are annualized quarterly geometric average returns; risk, defined as the annualized standard deviation of quarterly returns, appears beneath each currency return value. Currency hedges are perfect in the sense that the amount of currency sold forward reflects the stock's local currency return.

Table 7 Currency-Hedged Bond Risk and Return*

(1991 Q1 - 1995 Q4, in %)

C r o s s B o r d e r B o n d										
Base Currency	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
Australia		13.60 6.9	11.55 6.8	11.81 6.4	13.15 12.8	13.47 6.5	12.24 6.2	10.23 6.3	12.80 7.0	13.03 8.2
Canada	16.91 9.6		11.27 6.7	11.53 6.4	12.87 12.7	13.19 6.4	11.96 6.2	9.95 6.3	12.52 6.9	12.75 8.1
France	18.63 9.6	15.02 6.8		13.23 6.5	14.57 12.8	14.89 6.6	13.66 6.4	11.64 6.5	14.22 7.2	14.45 8.2
Germany	17.45 9.5	13.85 6.7	11.80 6.6		13.41 12.7	13.73 6.5	12.50 5.9	10.49 6.1	13.06 7.0	13.29 8.1
Italy	21.24 9.7	17.61 6.9	15.54 7.0	15.81 6.8		17.48 6.6	16.24 6.6	14.21 6.7	16.81 7.3	17.04 8.3
Japan	13.73 9.5	10.16 6.7	8.13 6.5	8.40 6.0	9.72 12.7		8.82 5.8	6.83 6.0	9.38 6.9	9.61 8.0
Netherlands	17.27 19.5	13.67 6.7	11.62 6.6	11.89 6.2	13.22 12.7	13.54 6.5		10.30 6.1	12.87 7.0	13.11 8.1
Switzerland	15.95 9.5	12.37 6.7	10.33 6.5	10.59 6.1	11.92 12.6	12.24 6.5	11.02 5.8		11.58 6.9	11.81 8.0
U.K.	18.13 9.8	14.53 6.9	12.47 6.8	12.74 6.4	14.08 12.8	14.40 6.6	13.17 6.2	11.16 6.3		13.96 8.2
U.S.	14.81 9.5	11.23 6.8	9.20 6.6	9.46 6.3	10.79 12.6	11.11 6.4	9.89 6.1	7.89 6.3	10.44 6.8	

* Returns are annualized quarterly geometric average returns; risk, defined as the annualized standard deviation of quarterly returns, appears beneath each currency return value. Currency hedges are perfect in the sense that the amount of currency sold forward reflects the bond's local currency return.

The results for absolute averages of paired values are summarized below:

	Stocks		Bonds	
	Return	Risk	Return	Risk
Currency-Unhedged	11.63%	17.99%	12.86%	14.12%
Currency-Hedged	11.62%	14.26%	12.85%	7.73%

It is interesting to note that hedging currency risk has little effect on the absolute average of paired returns, but does serve to reduce the average risk of paired returns. This finding tends to support the "free lunch" view of currency hedging whereby long-run returns are presumed to be unaffected by hedging, but where the average risk exposure to all parties is reduced. (See Perold and Schulman, 1988, and Black, 1989.) As we will see below, however, this result does not generally occur when we consider portfolios of cross-border investments from the point of view of a particular base-currency investor. While risk is often reduced, this is not always the case; and the return effects of currency hedging are typically non-zero for a given base currency investor.

Risk, Return and Diversification

One aim of portfolio diversification is to reduce risk by combining securities whose returns are less than perfectly correlated with each other. If this can be accomplished with little or no loss of return, then an improvement in risk-adjusted return is realized.

As shown in Equation (10) of Appendix A, the extent to which cross-border diversification reduces risk depends on a number of variables. These variables

include stock and bond returns in both base-currency and local currency terms, currency and forward premium returns, the proportion of the portfolio that is invested cross-border, and the proportion of the portfolio for which currency exposure is hedged. The interaction of these variables, as reflected in their variances and covariances, determines the effect that cross-border investing will have on portfolio risk.

In essence, the extent to which risk is reduced through cross-border diversification depends on the correlation between the returns on stocks and bonds denominated in the base currency and the returns on the cross-border investments measured in terms of the base currency. The lower the correlation, the greater the amount of risk reduction.

Currencies enter the picture when local-currency cross-border returns are converted to base currency returns. For currency-unhedged portfolios, and for a given correlation between local-currency and base currency asset returns, the amount of risk reduction achieved through cross-border investing will be inversely related to the correlation between local currency returns and currency returns. The amount of risk reduction will also be greater the greater the currency return volatility compared to the forward premium volatility.

Consider, for example, an Australian-dollar-based equity investor. The correlations between Australian stock returns and British and Dutch local-currency stock returns are .63 and .65 respectively, as shown below. In addition, the volatilities of local currency returns are roughly the same for all three countries, falling between, 12.0 and 13.1 percent.

The currency volatilities are not the same, however, since the currency return and forward premium volatilities are 18.3% and 1.2% for the Netherlands,

respectively, compared to 13.8% and 0.8% for Britain.

The reduction in overall portfolio risk is greater when Dutch stocks are added to the portfolio than when British stocks are added because Dutch currency returns are more volatile than British currency returns and because Australian currency returns are less correlated with Dutch stock returns than with British stock returns. Maximum risk reductions occur at roughly the same cross-border proportions, .31 for British stocks and .42 for Dutch stocks.

	VOL_{FX}	$CORR_{BPC, LC}$	$CORR_{LC, FX}$	Maximum Change in Portfolio Risk
British Stocks	18.3%	0.63	-0.34	0.9% (@ $w = .31$)
Dutch Stocks	13.8%	0.65	-0.65	-2.3% (@ $w = .42$)

Paired correlations between the return on a cross-border stock in local currency terms and the return on the cross-border currency in base currency terms are presented in Table 8. Correlation values range from -0.73 to 0.44; their average in absolute value terms is 0.30 and their arithmetic average is -0.09.

Paired correlations between the return on a cross-border bond in local currency terms and the return on the cross-border currency in base currency terms are presented in Table 9.

Correlation values range from -0.47 to 0.40; their average in absolute value terms is 0.19 and their arithmetic average is -0.11.

For currency-hedged portfolios, and for a given correlation between local-currency and base currency asset returns, the amount of risk reduction achieved through cross-border investing will be inversely related to the correlation between local currency returns and the forward premiums.

Table 8 Return Correlations: Stocks vs. Currencies*
(1991 Q1 - 1995 Q4, in %)

Base Currency	Cross - Border Stock and Currency									
	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
Australia		0.37	-0.48	-0.64	-0.30	-0.28	-0.65	-0.59	-0.34	0.23
Canada	-0.29		-0.54	-0.65	-0.33	-0.19	-0.73	-0.70	-0.47	-0.48
France	0.29	0.33		-0.24	0.34	-0.07	-0.51	-0.27	0.34	0.04
Germany	0.27	0.37	0.12		0.30	-0.06	-0.26	-0.03	0.35	0.04
Italy	0.19	0.22	0.01	-0.31		-0.20	-0.30	-0.37	0.32	0.10
Japan	0.13	0.11	-0.26	-0.21	-0.24		-0.28	-0.33	0.11	0.11
Netherlands	0.27	0.37	0.14	0.33	0.30	-0.06		-0.01	0.34	0.03
Switzerland	0.28	0.31	0.34	0.29	0.33	-0.14	0.02		0.31	0.05
U.K.	0.05	0.20	-0.40	-0.67	0.04	-0.09	-0.63	-0.49		0.05
U.S.	-0.06	0.44	-0.52	-0.62	-0.37	-0.24	-0.69	-0.71	-0.34	

* Simple correlations between the return on a cross-border stock in local currency terms and the return on the cross-border currency in base currency terms.

Table 9 Return Correlations: Bonds vs. Currencies*

(1991 Q1 - 1995 Q4, in %)

Base Currency	Cross - Border Stock and Currency									
	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
Australia		0.32	-0.20	-0.16	-0.39	0.08	-0.28	-0.18	0.03	0.40
Canada	-0.40		-0.37	-0.35	-0.41	-0.05	-0.43	-0.32	0.00	-0.24
France	-0.25	-0.09		-0.17	0.19	-0.18	-0.32	-0.05	0.18	-0.38
Germany	-0.23	-0.08	0.12		0.16	-0.20	-0.27	0.00	0.15	-0.37
Italy	-0.38	-0.17	-0.13	-0.01		0.09	-0.20	0.24	0.09	-0.26
Japan	-0.13	0.06	-0.17	-0.18	-0.11		-0.06	-0.13	0.16	-0.17
Netherlands	-0.22	-0.07	0.15	0.23	0.16	-0.20		0.02	0.16	-0.36
Switzerland	-0.20	-0.09	0.10	0.13	0.17	-0.14	0.06		0.17	-0.35
U.K.	-0.37	-0.10	-0.14	0.02	0.08	-0.10	-0.12	0.14		-0.26
U.S.	-0.34	0.00	-0.40	-0.38	-0.47	0.00	-0.45	-0.32	-0.02	

* Simple correlations between the return on a cross-border bond in local currency terms and the return on the cross-border currency in base currency terms.

Equally-Weighted Stock Portfolios

One approach to cross-border diversification is to hold equally-weighted positions in cross-border securities. The results of such an approach for stocks are summarized in Table 10.

Since the overall base-currency return is linearly related to the proportion invested cross-border, we can generalize about the return benefits of going cross-border. Five of the ten base currency investors improved their return by going cross-border, regardless of whether or not they hedged currency risk: Canada, France, Germany, Italy and Japan. Four investors lowered their return: Australia, Holland, Switzerland and the U.S. The remaining investor, the U.K., improved return if currency exposure was not hedged and lowered return if currency exposure was hedged.

It is more difficult to generalize about the risk effects of going cross-border since the relationships are non-linear. When compared to the volatility of own-currency stock returns, currency-unhedged cross-border stock volatilities were lower in six of the ten cases. However, currency-hedged stock volatilities were lower in eight of the ten cases (the exceptions were Canada and the U.S.)

As noted above, one reason for diversifying cross-border is to reduce portfolio risk. It is possible to gain insight into the matter of just how much risk can be eliminated through cross-border diversification by looking at portfolios for which cross-border investments are equally-weighted.

In particular, the impact on portfolio risk and return can be measured using optimal (risk-minimizing) combinations of w , the proportion invested cross-border, and h , the proportion of the cross-border investment that is hedged. In essence, when compared to the base-currency portfolio, we can show what happens to risk

and return when total portfolio risk is minimized. These results are summarized in Table 11.

As shown in Table 11, total portfolio risk was lowered in each of the ten base-currency countries when optimal w and h values were chosen. This risk reduction averaged roughly five and one-half percent. The effect on return was mixed, however, with five countries experiencing improved returns (Canada, France, Germany, Italy and Japan) and five countries experiencing lower returns (Australia, the Netherlands, Switzerland, the U.K. and the U.S.) On average, return improved roughly six-tenths of one percent in the ten countries.

Interestingly, five countries had optimal w and h values equal to or nearly equal to 1.0. These countries were France, Germany, Italy, the Netherlands and Switzerland. While optimal h values equaled 1.0 in six of the ten countries, optimal w values equaled 1.0 in four of the ten countries. Optimal w and h values averaged 0.90 and 0.81 respectively.

Equally-Weighted Bond Portfolios

A similar analysis was performed on bond portfolios. As shown in Table 12, total portfolio risk was lowered in each of the ten base-currency countries when optimal w and h values were chosen. This risk reduction averaged roughly two percent.

The effect on return was mixed, however, with six countries experiencing improved returns (France, Germany, the Netherlands, Switzerland, and the U.K.) and four countries experiencing lower returns (Australia, Canada, Italy and Japan.) On average, there was a negligible (0.03 percent) improvement in return.

**Table 10 Risk and Return for an Equally-Weighted
Portfolio of Cross-Border Stocks***
(1991 Q1 - 1995 Q4, in %)

Country	Own Currency		Currency Unhedged		Currency Hedged	
	Return	Risk	Return	Risk	Return	Risk
Australia	14.18	12.6	12.62	11.3	12.04	9.5
Canada	9.03	8.7	16.03	8.0	12.30	10.2
France	8.55	14.2	11.47	14.8	14.24	9.7
Germany	8.76	15.4	11.35	15.6	12.90	9.3
Italy	9.40	22.7	20.10	15.4	16.87	9.4
Japan	-0.08	20.6	6.84	15.6	9.61	10.1
Netherlands	16.52	12.0	10.49	15.7	11.88	9.3
Switzerland	20.34	14.9	8.67	16.4	10.00	9.0
U.K.	14.01	13.1	16.78	11.3	13.09	9.5
U.S.	15.44	9.1	11.59	8.0	9.27	10.0
Mean	11.62	14.3	12.59	13.2	12.22	9.6

* For a given country, the cross-border portfolio consists of equally-weighted investments in each of the securities of the nine other countries.

Table 11 Risk and Return Effects for Stock Portfolios
When Optimal w and h Values Are Chosen*
 (1991 Q1 - 1995 Q4, in %)

Country	Optimal		Portfolio Risk Effect			Portfolio Return Effect		
	w	h	Base	Total	Change	Base	Total	Change
Australia	1.00	0.64	12.58	7.83	-4.75	14.18	12.05	-2.13
Canada	0.59	0.21	8.67	6.33	-2.34	9.03	12.68	3.65
France	0.98	1.00	14.22	9.86	-4.36	8.55	14.40	5.85
Germany	1.00	1.00	15.38	9.60	-5.78	8.76	13.28	4.52
Italy	1.00	1.00	22.68	9.69	-12.99	9.40	17.06	7.66
Japan	0.82	1.00	20.63	9.07	-11.56	-0.08	7.79	7.87
Netherlands	1.00	1.00	11.98	9.58	-2.40	16.52	12.30	-4.22
Switzerland	1.00	1.00	14.89	9.17	-5.72	20.34	10.45	-9.89
U.K.	0.93	0.89	13.05	9.66	-3.39	14.01	9.81	-4.20
U.S.	0.64	0.33	9.12	6.99	-2.13	15.44	12.44	-3.00
Mean	0.90	0.81	14.32	8.78	-5.54	11.62	12.23	0.61

* For a given country, the cross-border portfolio consists of equally-weighted investments in each of the securities of the nine other countries. Optimal w and optimal h refer respectively to the proportion invested cross-border and to the proportion of the cross-border investment that is currency-hedged.

With regard to minimizing total portfolio risk by choosing optimal w and h values, total portfolio risk was lowered in each of the ten base-currency countries when optimal w and h values were chosen, as shown in Table 13. This risk reduction averaged roughly two percent. The effect on return was mixed, however, with six countries experiencing improved returns (France, Germany, the Netherlands, Switzerland, the U.K. and the U.S.) and four countries experiencing lower returns (Australia, Canada, Italy and Japan.) On average, return improved by 0.03 percent in the ten countries.

While optimal h values equaled 1.0 in eight of the ten countries, optimal w values equaled 1.0 in four of the ten countries. Optimal w and h values averaged 0.81 and 0.97 respectively.

Looked at comparatively, cross-border bonds should be more fully currency-hedged than cross-border stocks, with average optimal (risk-minimizing) hedge ratios being .97 and .81 respectively. Optimal average cross-border proportions are high for both stocks and bonds, falling in the .80 to .90 range.

Recent Risk Trends

Market Volatility

Currency managers are presumably interested in knowing if there are any trends in the role that currency returns play in determining base-currency terms, especially with regard to return volatility or risk. Insight into any such trends can be provided by analyzing a time series that is defined as the ratio of currency-unhedged return volatility to local market return volatility. (See Nesbitt, 1991.)

**Table 12 Risk and Return for an Equally-Weighted
Portfolio of Cross-Border Bonds***
(1991 Q1 - 1995 Q4, in %)

Country	Own Currency		Currency Unhedged		Currency Hedged	
	Return	Risk	Return	Risk	Return	Risk
Australia	17.19	9.8	13.13	14.7	12.56	5.7
Canada	13.31	6.8	16.42	11.0	12.69	5.8
France	12.96	6.9	11.85	9.1	14.62	5.9
Germany	12.07	6.2	11.87	10.1	13.43	5.8
Italy	17.16	12.9	20.18	12.6	16.96	6.1
Japan	10.04	6.5	6.78	14.0	9.55	5.8
Netherlands	12.31	5.9	11.80	10.2	13.20	5.8
Switzerland	9.01	6.1	10.77	11.7	12.11	5.8
U.K.	13.73	7.1	17.68	9.4	13.99	6.0
U.S.	10.67	8.0	12.99	9.6	10.66	5.7
Mean	12.85	7.6	13.35	11.2	12.98	5.8

* For a given country, the cross-border portfolio consists of equally-weighted investments in each of the securities of the nine other countries.

Table 13 Risk and Return Effects for Bond Portfolios

When Optimal w and h Values Are Chosen*

(1991 Q1 - 1995 Q4, in %)

Country	Optimal		Portfolio Risk Effect			Portfolio Return Effect		
	w	h	Base	Total	Change	Base	Total	Change
Australia	1.00	1.00	9.80	5.71	-4.09	17.19	12.56	-4.63
Canada	1.00	0.87	6.75	5.62	-1.13	13.31	13.20	-0.11
France	1.00	1.00	6.87	5.87	-1.00	12.96	14.57	1.61
Germany	0.68	1.00	6.20	5.62	-0.58	12.07	13.00	0.93
Italy	0.96	1.00	12.93	6.05	-6.88	17.16	17.07	-0.09
Japan	0.59	1.00	6.45	5.38	-1.07	10.04	9.73	-0.31
Netherlands	0.54	1.00	5.93	5.48	-0.45	12.31	12.80	0.49
Switzerland	0.57	1.00	6.06	5.33	-0.73	9.01	10.80	1.79
U.K.	0.78	1.00	7.05	5.89	-1.16	13.73	14.05	0.32
U.S.	1.00	0.85	7.97	5.56	-2.41	10.67	10.99	0.32
Mean	0.81	0.97	7.60	5.65	-1.95	12.85	12.88	0.03

* For a given country, the cross-border portfolio consists of equally-weighted investments in each of the securities of the nine other countries. Optimal w and optimal h refer respectively to the proportion invested cross-border and to the proportion of the cross-border investment that is currency-hedged.

In essence, such ratios provide one measure of the extent to which currency return fluctuations affect base currency returns. When ratios exceed unity, the currency component adds to risk; when ratios are less than unity, the currency component tends to reduce risk.

Ratio time series were constructed for equally-weighted cross-border portfolios for each of the ten countries. Results for stocks and bonds are presented in Tables 14 and 15 respectively.

A number of insights are apparent. First, the average ratio for stocks was 1.16 compared to 1.77 for bonds. The fact that the bond ratio average is higher than the stock average ratio suggests that currency risk is more important for bonds investors than for stock investors. This finding is consistent with both academic research and investment practice. Cross-border bond portfolios tend to be hedged more often, and in greater proportion, than cross-border stock portfolios.

Second, with regard to stock portfolios, ratios tend to exceed unity in all countries except Canada and the U.S. Stock ratios also appear to be trending upward more or less in the other eight countries. As reflected in the time series regression coefficient and related t-statistics in Table 14, statistically significant uptrends in the ratios occurred in all countries except Canada, Britain and the U.S. This suggests that cross-border stock portfolios in these seven countries are facing increasing currency risk exposure relative to local currency risk. Interestingly, for the U.S., the ratio has been trending downward, suggesting that currency risk relative to local currency risk has been declining.

Third, with regard to bond portfolios, ratios exceed unity in every quarter in each country. In addition, ratios appear to be trending upward in most countries. As shown in Table 15, statistically significant uptrends occurred in France, Germany, Japan, the Netherlands and Switzerland. Similarly, statistically significant downtrends occurred in Canada and the U.S. This suggests that while cross-border bond portfolios in most countries are facing increasing currency risk

exposure relative to local currency exposure, some countries appear to be facing less currency risk exposure relative to local currency exposure.

Correlations

Correlation trends also provide insight into the roles that currencies and currency-hedging play in shaping base currency returns. Insight into correlation patterns can be obtained by constructing time series of moving, five-year correlations for own-currency portfolios versus equally-weighted cross-border portfolios in each of the ten countries. Correlation results for currency-unhedged and currency-hedged stock portfolios are presented in Tables 16 and 17, respectively, while results for currency-unhedged and currency-hedged bond portfolios are presented in Tables 18 and 19, respectively.

First, with regard to stock portfolios, statistically significant downtrends in correlations occurred in several countries, as shown in Tables 16 and 17. These downtrends, which occurred for both currency-unhedged and currency-hedged investments, were experienced by six countries: Australia, Canada, Italy, Japan, Britain and the U.S. This suggests that, other things equal, the risk reduction benefits of cross-border stock investing have been increasing in these countries.

Second, with regard to bond portfolios, the results were mixed. For currency-unhedged bond portfolios, statistically significant correlation uptrends occurred in all but one country--Canada. This suggests declining risk reduction benefits from unhedged cross-border bond investments.

For currency-hedged bond portfolios, however, statistically significant correlation uptrends occurred in four countries (Australia, Canada, France and Britain) while statistically significant correlation downtrends occurred in four other countries (Germany, Japan, the Netherlands and Switzerland.) This suggests that risk reduction benefits from cross-border investing may be declining in the former group of countries while increasing in the latter group of countries.

**Table 14 Ratio of Currency-Unhedged Return Volatility to
Local Market Return Volatility for Stocks***
(1991 Q1 - 1995 Q4, in %)

Year	Qtr	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
1990	Q1	1.06	1.04	1.07	1.12	1.09	1.11	1.10	1.20	1.16	1.03
	Q2	1.04	1.04	1.07	1.12	1.09	1.11	1.10	1.20	1.18	1.03
	Q3	1.03	0.97	1.06	1.08	1.05	1.12	1.07	1.18	1.16	0.97
	Q4	0.98	0.90	1.08	1.11	1.08	1.14	1.10	1.19	1.16	0.94
1991	Q1	0.95	0.78	1.13	1.17	1.12	1.19	1.16	1.27	1.16	0.85
	Q2	0.95	0.80	1.13	1.16	1.11	1.19	1.15	1.26	1.16	0.86
	Q3	0.89	0.80	1.14	1.16	1.11	1.18	1.15	1.25	1.13	0.86
	Q4	0.92	0.80	1.15	1.17	1.12	1.17	1.16	1.26	1.13	0.85
1992	Q1	0.93	0.79	1.15	1.19	1.11	1.18	1.17	1.28	1.15	0.81
	Q2	0.94	0.79	1.16	1.20	1.11	1.18	1.18	1.29	1.16	0.82
	Q3	0.93	0.79	1.18	1.21	1.11	1.20	1.20	1.33	1.15	0.82
	Q4	1.06	0.85	1.32	1.32	1.24	1.18	1.30	1.50	1.24	0.92
1993	Q1	1.06	0.86	1.30	1.30	1.30	1.18	1.29	1.48	1.25	0.93
	Q2	1.05	0.87	1.30	1.30	1.30	1.18	1.27	1.45	1.22	0.95
	Q3	1.07	0.92	1.29	1.29	1.31	1.18	1.26	1.43	1.22	0.95
	Q4	1.05	0.89	1.29	1.31	1.33	1.21	1.28	1.43	1.20	0.90
1994	Q1	1.06	0.89	1.29	1.31	1.36	1.23	1.28	1.40	1.20	0.89
	Q2	1.05	0.89	1.29	1.31	1.36	1.17	1.29	1.41	1.17	0.89
	Q3	1.05	0.88	1.31	1.34	1.39	1.18	1.31	1.43	1.20	0.85
	Q4	1.07	0.88	1.30	1.32	1.39	1.13	1.30	1.43	1.18	0.84
1995	Q1	1.13	0.86	1.32	1.37	1.39	1.14	1.34	1.47	1.16	0.81
	Q2	1.14	0.85	1.32	1.36	1.38	1.13	1.34	1.48	1.16	0.80
	Q3	1.31	0.80	1.57	1.68	1.67	1.52	1.67	1.78	1.19	0.79
	Q4	1.19	0.80	1.57	1.67	1.69	1.53	1.67	1.78	1.19	0.79
Slope		0.009	-0.003	0.018	0.019	0.023	0.008	0.018	0.020	0.002	-0.006
t-statistic		4.49	-1.59	10.13	8.60	10.86	2.89	7.76	8.44	1.76	-3.56

* Volatility ratios are based on the standard deviations of quarterly returns calculated over a five-year lookback. Slope is the regression coefficient of a time series regression fit to the quarterly data; t-statistic is the t-statistic associated with this regression coefficient.

Table 15 Ratio of Currency-Unhedged Return Volatility to
Local Market Return Volatility for Bonds*
(1991 Q1 - 1995 Q4, in %)

Year	Qtr	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
1990	Q1	2.24	2.11	1.23	1.23	1.26	1.19	1.24	1.27	1.55	2.19
	Q2	2.21	2.13	1.26	1.25	1.29	1.18	1.26	1.28	1.59	2.22
	Q3	2.19	1.98	1.27	1.24	1.24	1.23	1.25	1.30	1.61	2.10
	Q4	2.20	1.88	1.22	1.17	1.18	1.21	1.18	1.29	1.54	2.01
1991	Q1	2.51	2.04	1.44	1.42	1.37	1.44	1.44	1.58	1.67	2.14
	Q2	2.34	2.04	1.46	1.47	1.37	1.50	1.48	1.62	1.72	2.14
	Q3	2.13	2.08	1.41	1.38	1.28	1.50	1.39	1.51	1.49	2.18
	Q4	2.32	2.21	1.40	1.35	1.24	1.45	1.37	1.50	1.46	2.23
1992	Q1	2.46	2.28	1.43	1.39	1.23	1.49	1.41	1.58	1.49	2.25
	Q2	2.56	2.36	1.46	1.42	1.23	1.50	1.43	1.61	1.53	2.29
	Q3	2.99	2.56	1.57	1.56	1.48	1.57	1.57	1.87	1.86	2.43
	Q4	2.82	2.30	1.69	1.65	1.73	1.54	1.64	1.98	1.99	2.17
1993	Q1	2.71	2.21	1.60	1.57	1.90	1.56	1.58	1.91	1.96	2.16
	Q2	2.41	2.09	1.66	1.63	1.97	1.69	1.61	1.90	1.95	2.09
	Q3	2.35	2.10	1.63	1.57	2.00	1.67	1.55	1.83	1.88	2.00
	Q4	2.36	2.07	1.64	1.63	2.02	1.71	1.62	1.84	1.84	1.92
1994	Q1	2.37	2.04	1.73	1.75	2.19	1.95	1.71	2.00	1.97	1.86
	Q2	2.14	1.76	1.59	1.62	1.98	1.57	1.60	1.83	1.74	1.59
	Q3	2.07	1.75	1.56	1.57	1.94	1.50	1.56	1.79	1.68	1.53
	Q4	2.18	1.76	1.48	1.48	1.88	1.36	1.47	1.78	1.67	1.55
1995	Q1	2.74	1.94	1.59	1.66	2.14	1.58	1.65	1.98	1.71	1.72
	Q2	2.67	1.87	1.56	1.63	2.08	1.53	1.64	1.96	1.65	1.65
	Q3	2.83	1.94	1.58	1.69	2.17	2.27	1.70	1.96	1.62	1.70
	Q4	2.62	1.91	1.59	1.73	2.22	2.33	1.74	1.96	1.63	1.66
Slope		0.012	-0.012	0.016	0.021	0.050	0.030	0.020	0.031	0.008	-0.030
t-statistic		1.71	-2.16	5.43	8.07	10.31	4.98	8.03	8.18	1.66	-5.92

* Volatility ratios are based on the standard deviations of quarterly returns calculated over a five-year lookback. Slope is the regression coefficient of a time series regression fit to the quarterly data; t-statistic is the t-statistic associated with this regression coefficient.

First, with regard to stock portfolios, statistically significant downtrends in correlations occurred in several countries, as shown in Tables 16 and 17. These downtrends, which occurred for both currency-unhedged and currency-hedged investments, were experienced by six countries: Australia, Canada, Italy, Japan, Britain and the U.S. This suggests that, other things equal, the risk reduction benefits of cross-border stock investing have been increasing in these countries.

Second, with regard to bond portfolios, the results were mixed. For currency-unhedged bond portfolios, statistically significant correlation uptrends occurred in all but one country—Canada. This suggests declining risk reduction benefits from unhedged cross-border bond investments.

For currency-hedged bond portfolios, however, statistically significant correlation uptrends occurred in four countries (Australia, Canada, France and Britain) while statistically significant correlation downtrends occurred in four other countries (Germany, Japan, the Netherlands and Switzerland.) This suggests that risk reduction benefits from cross-border investing may be declining in the former group of countries while increasing in the latter group of countries.

Optimal (Risk-Minimizing) Hedge Ratios

Relationships between the amount invested cross-border and the optimal (risk-minimizing) proportion of currency exposure to hedge in the forward market are summarized in Tables 20 and 21 for stock and bond portfolios respectively. A number of insights can be found in these tables.

First, calculation of optimal hedge ratios in this manner essentially treats

currencies as a separate asset class. Optimizations determines how large a currency position should be taken to minimize portfolio risk. It also determines whether the currency position should be long (whereby the amount of cross-border currency purchased exceeds the amount required to purchase cross-border stocks and bonds) or whether it should be short (whereby cross-border currency is sold in an amount that may be greater or less than the amount associated with investment in the cross-border stocks and bonds).

Second, as can readily be seen, optimal hedge ratios are highly diverse, varying over a wide range of values, both positive and negative. When hedge ratios outside of the 0 to 1 range are applied, currencies are, in essence, being viewed as a separate asset class.

Third, optimal hedge ratios tend to decline (in absolute terms) as the proportion of cross-border investment increases. This suggests that currencies play a larger role in minimizing risk when the level of cross-border investment is low; their role becomes less important as greater diversification is achieved by increasing the level of cross-border investment.

Fourth, optimal hedge ratios become exceptionally large (in absolute value terms) for very small levels of cross-border investment. This might provide some rationale for the fact that investors with small (under 5 percent) cross-border exposure tend not to hedge their currency risk.

Table 16 Currency-Unhedged Return Correlations for Own-Currency
vs. Equally-Weighted Cross-Border Stock Portfolios*
(1991 Q1 -- 1995 Q4, in %)

Year	Qtr	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
1990	Q1	0.46	0.58	0.76	0.55	0.52	0.34	0.87	0.74	0.74	0.72
	Q2	0.47	0.57	0.77	0.54	0.52	0.34	0.87	0.73	0.73	0.72
	Q3	0.49	0.67	0.82	0.66	0.62	0.52	0.89	0.79	0.78	0.85
	Q4	0.52	0.65	0.83	0.66	0.60	0.52	0.89	0.83	0.77	0.82
1991	Q1	0.51	0.73	0.84	0.65	0.74	0.52	0.93	0.89	0.75	0.81
	Q2	0.51	0.72	0.83	0.64	0.74	0.54	0.93	0.89	0.74	0.81
	Q3	0.53	0.73	0.82	0.65	0.81	0.59	0.93	0.89	0.81	0.88
	Q4	0.55	0.73	0.82	0.65	0.81	0.60	0.93	0.89	0.81	0.88
1992	Q1	0.53	0.79	0.81	0.74	0.83	0.57	0.93	0.93	0.82	0.86
	Q2	0.54	0.78	0.86	0.74	0.84	0.57	0.94	0.92	0.84	0.86
	Q3	0.54	0.77	0.87	0.75	0.78	0.51	0.95	0.89	0.84	0.85
	Q4	0.23	0.59	0.78	0.57	0.75	0.45	0.89	0.82	0.73	0.74
1993	Q1	0.25	0.63	0.83	0.58	0.75	0.42	0.87	0.84	0.72	0.72
	Q2	0.34	0.66	0.81	0.55	0.69	0.37	0.87	0.84	0.73	0.71
	Q3	0.38	0.60	0.82	0.54	0.71	0.37	0.87	0.84	0.73	0.69
	Q4	0.34	0.55	0.83	0.57	0.69	0.31	0.88	0.84	0.73	0.71
1994	Q1	0.37	0.58	0.83	0.59	0.57	0.24	0.87	0.84	0.72	0.70
	Q2	0.36	0.60	0.83	0.60	0.58	0.23	0.88	0.85	0.75	0.73
	Q3	0.32	0.48	0.82	0.59	0.57	0.19	0.87	0.85	0.74	0.69
	Q4	0.37	0.48	0.84	0.66	0.56	0.16	0.87	0.85	0.74	0.71
1995	Q1	0.34	0.42	0.82	0.76	0.53	0.33	0.87	0.85	0.72	0.69
	Q2	0.36	0.44	0.82	0.78	0.53	0.30	0.89	0.86	0.74	0.68
	Q3	0.20	0.14	0.68	0.67	0.35	0.18	0.85	0.80	0.59	0.41
	Q4	0.37	0.13	0.68	0.69	0.35	0.20	0.85	0.80	0.62	0.40
Slope		-0.011	-0.017	-0.002	0.003	-0.010	-0.015	-0.002	0.001	-0.005	-0.012
t-statistic		-4.51	-4.75	-1.37	1.17	-2.58	-4.90	-2.78	0.38	-3.19	-4.63

* Correlations are based on quarterly returns over a five-year lookback. Slope is the regression coefficient of a time series regression fit to the quarterly data; t-statistic is the t-statistic associated with this regression coefficient.

**Table 17 Currency-Hedged Return Correlations for Own-Currency
vs. Equally-Weighted Cross-Border Stock Portfolios***

(1991 Q1 - 1995 Q4, in %)

Year	Qtr	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
1990	Q1	0.68	0.75	0.78	0.61	0.58	0.58	0.85	0.75	0.80	0.85
	Q2	0.69	0.75	0.78	0.61	0.58	0.59	0.85	0.74	0.84	0.84
	Q3	0.68	0.77	0.86	0.72	0.68	0.70	0.88	0.80	0.87	0.89
	Q4	0.72	0.76	0.84	0.70	0.67	0.73	0.87	0.82	0.86	0.88
1991	Q1	0.75	0.78	0.84	0.70	0.78	0.70	0.91	0.90	0.85	0.88
	Q2	0.75	0.78	0.83	0.69	0.79	0.70	0.91	0.90	0.85	0.89
	Q3	0.74	0.79	0.83	0.69	0.81	0.73	0.91	0.90	0.86	0.93
	Q4	0.74	0.78	0.83	0.69	0.82	0.74	0.92	0.90	0.85	0.91
1992	Q1	0.73	0.89	0.81	0.81	0.84	0.69	0.91	0.95	0.86	0.92
	Q2	0.72	0.89	0.86	0.81	0.84	0.68	0.93	0.96	0.88	0.92
	Q3	0.80	0.89	0.87	0.79	0.83	0.63	0.94	0.96	0.87	0.91
	Q4	0.60	0.78	0.79	0.62	0.75	0.62	0.86	0.92	0.77	0.82
1993	Q1	0.60	0.78	0.83	0.63	0.75	0.65	0.86	0.92	0.77	0.82
	Q2	0.58	0.76	0.87	0.61	0.76	0.67	0.85	0.92	0.76	0.80
	Q3	0.56	0.79	0.87	0.63	0.77	0.67	0.86	0.91	0.77	0.80
	Q4	0.62	0.78	0.89	0.65	0.76	0.60	0.85	0.90	0.80	0.77
1994	Q1	0.67	0.77	0.89	0.67	0.67	0.56	0.86	0.90	0.81	0.76
	Q2	0.66	0.76	0.89	0.67	0.68	0.51	0.86	0.91	0.83	0.76
	Q3	0.63	0.69	0.88	0.66	0.67	0.49	0.86	0.89	0.83	0.74
	Q4	0.65	0.69	0.88	0.69	0.67	0.49	0.85	0.90	0.83	0.74
1995	Q1	0.64	0.65	0.88	0.82	0.68	0.47	0.85	0.90	0.82	0.66
	Q2	0.66	0.69	0.88	0.83	0.68	0.45	0.86	0.90	0.82	0.67
	Q3	0.66	0.51	0.71	0.66	0.52	0.05	0.83	0.80	0.72	0.39
	Q4	0.73	0.51	0.71	0.67	0.52	0.04	0.84	0.79	0.73	0.40
Slope		-0.004	-0.008	0.001	0.001	-0.004	-0.019	-0.002	0.002	-0.004	-0.016
t-statistic		-2.10	-3.69	0.37	0.63	-1.53	-4.91	-2.62	1.15	-3.32	-6.10

* Correlations are based on quarterly returns over a five-year lookback. Slope is the regression coefficient of a time series regression fit to the quarterly data; t-statistic is the t-statistic associated with this regression coefficient.

Table 18 Currency-Unhedged Return Correlations for Own-Currency
vs. Equally-Weighted Cross-Border Bond Portfolios*
(1991 Q1 - 1995 Q4, in %)

Year	Qtr	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
1990	Q1	-0.00	0.51	0.77	0.61	0.14	-0.14	0.57	0.29	0.21	0.45
	Q2	-0.01	0.53	0.76	0.58	0.16	-0.18	0.55	0.24	0.19	0.46
	Q3	-0.00	0.55	0.78	0.71	0.13	-0.01	0.62	0.33	0.19	0.51
	Q4	0.16	0.54	0.81	0.70	0.11	0.09	0.62	0.33	0.21	0.53
1991	Q1	0.08	0.45	0.79	0.65	0.12	0.09	0.57	0.37	0.07	0.39
	Q2	0.11	0.47	0.76	0.66	0.38	0.08	0.57	0.38	0.05	0.42
	Q3	0.25	0.52	0.81	0.74	0.44	0.16	0.70	0.48	0.18	0.49
	Q4	0.30	0.55	0.84	0.69	0.47	0.16	0.66	0.48	0.19	0.52
1992	Q1	0.33	0.55	0.84	0.69	0.45	0.16	0.65	0.44	0.24	0.59
	Q2	0.38	0.58	0.88	0.69	0.45	0.15	0.64	0.47	0.22	0.60
	Q3	0.36	0.53	0.86	0.56	0.33	0.01	0.54	0.19	0.06	0.58
	Q4	0.49	0.47	0.87	0.62	0.37	0.14	0.64	0.34	0.11	0.54
1993	Q1	0.51	0.49	0.86	0.61	0.43	0.08	0.64	0.41	0.14	0.55
	Q2	0.56	0.52	0.86	0.67	0.36	0.13	0.71	0.42	0.16	0.54
	Q3	0.55	0.52	0.87	0.66	0.42	0.17	0.71	0.41	0.16	0.55
	Q4	0.52	0.51	0.88	0.69	0.45	0.24	0.68	0.43	0.16	0.57
1994	Q1	0.53	0.47	0.87	0.70	0.43	0.30	0.67	0.50	0.18	0.57
	Q2	0.67	0.58	0.88	0.75	0.46	0.41	0.74	0.56	0.43	0.74
	Q3	0.68	0.60	0.89	0.76	0.48	0.40	0.75	0.58	0.47	0.76
	Q4	0.69	0.60	0.88	0.75	0.44	0.56	0.73	0.57	0.50	0.76
1995	Q1	0.64	0.54	0.84	0.69	0.34	0.70	0.70	0.43	0.33	0.73
	Q2	0.65	0.52	0.84	0.72	0.32	0.71	0.73	0.48	0.37	0.73
	Q3	0.62	0.53	0.84	0.69	0.31	0.38	0.72	0.43	0.33	0.77
	Q4	0.55	0.51	0.81	0.67	0.30	0.29	0.72	0.48	0.37	0.76
Slope		0.032	0.001	0.004	0.003	0.009	0.027	0.007	0.009	0.011	0.015
t-statistic		12.63	1.05	3.82	2.01	2.77	7.23	6.49	3.83	3.88	8.92

* Correlations are based on quarterly returns over a five-year lookback. Slope is the regression coefficient of a time series regression fit to the quarterly data; t-statistic is the t-statistic associated with this regression coefficient.

Table 19 Currency-Hedged Return Correlations for Own-Currency
vs. Equally-Weighted Cross-Border Bond Portfolios*
(1991 Q1 - 1995 Q4, in %)

Year	Qtr	A\$	C\$	FF	DM	IL	JY	DG	SF	BP	US\$
1990	Q1	0.29	0.69	0.83	0.85	0.31	0.78	0.83	0.73	0.60	0.66
	Q2	0.28	0.68	0.83	0.84	0.35	0.78	0.83	0.71	0.62	0.65
	Q3	0.29	0.70	0.83	0.90	0.32	0.76	0.83	0.72	0.61	0.70
	Q4	0.37	0.77	0.84	0.91	0.28	0.78	0.83	0.68	0.65	0.77
1991	Q1	0.21	0.84	0.76	0.89	0.23	0.78	0.79	0.64	0.57	0.63
	Q2	0.22	0.82	0.75	0.90	0.27	0.79	0.80	0.68	0.56	0.65
	Q3	0.26	0.82	0.78	0.90	0.22	0.80	0.82	0.66	0.59	0.66
	Q4	0.26	0.84	0.85	0.90	0.22	0.82	0.84	0.65	0.59	0.70
1992	Q1	0.30	0.85	0.85	0.86	0.18	0.81	0.80	0.63	0.62	0.71
	Q2	0.28	0.83	0.87	0.88	0.06	0.81	0.81	0.63	0.65	0.71
	Q3	0.37	0.79	0.82	0.88	-0.09	0.77	0.80	0.65	0.56	0.65
	Q4	0.46	0.77	0.83	0.87	-0.07	0.77	0.80	0.64	0.56	0.60
1993	Q1	0.43	0.75	0.84	0.88	-0.01	0.77	0.81	0.65	0.55	0.63
	Q2	0.43	0.75	0.86	0.88	0.01	0.76	0.81	0.66	0.54	0.62
	Q3	0.42	0.75	0.87	0.87	0.10	0.77	0.80	0.66	0.56	0.60
	Q4	0.44	0.75	0.90	0.87	0.13	0.78	0.79	0.67	0.57	0.57
1994	Q1	0.44	0.79	0.90	0.85	0.08	0.79	0.74	0.63	0.66	0.61
	Q2	0.65	0.84	0.93	0.88	0.22	0.74	0.82	0.71	0.86	0.70
	Q3	0.69	0.85	0.94	0.89	0.28	0.75	0.82	0.71	0.85	0.70
	Q4	0.72	0.87	0.94	0.89	0.27	0.75	0.82	0.67	0.85	0.72
1995	Q1	0.71	0.83	0.94	0.85	0.27	0.67	0.75	0.58	0.82	0.68
	Q2	0.74	0.85	0.94	0.86	0.29	0.69	0.77	0.61	0.80	0.71
	Q3	0.73	0.84	0.94	0.84	0.34	0.66	0.73	0.58	0.79	0.69
	Q4	0.72	0.84	0.93	0.83	0.41	0.56	0.78	0.66	0.77	0.67
Slope		0.024	0.004	0.007	-0.001	0.000	-0.006	-0.003	-0.003	0.011	0.000
t-statistic		10.09	3.05	7.74	-2.12	0.08	-4.59	-4.15	-2.76	4.40	-0.03

* Correlations are based on quarterly returns over a five-year lookback. Slope is the regression coefficient of a time series regression fit to the quarterly data; t-statistic is the t-statistic associated with this regression coefficient.

Table 20 Optimal Hedge Ratios for Equally-Weighted
 Cross-Border Stock Portfolios*
 (1991 Q1 - 1995 Q4, in %)

Country	Percent Invested Cross-Border										
	1	2.5	5	7.5	10	15	20	25	50	75	100
Australia	-16.13	-5.97	-2.58	-1.45	-0.88	-0.32	-0.03	0.13	0.47	0.59	0.64
Canada	-26.43	-10.17	-4.75	-2.94	-2.04	-1.14	-0.69	-0.42	0.13	0.31	0.40
France	107.45	43.58	22.30	15.20	11.65	8.10	6.33	5.27	3.14	2.43	2.07
Germany	121.51	48.99	24.81	16.75	12.72	8.69	6.68	5.47	3.05	2.25	1.84
Italy	4.61	2.50	1.80	1.56	1.44	1.33	1.27	1.23	1.16	1.14	1.13
Japan	39.95	16.35	8.48	5.86	4.55	3.24	2.58	2.19	1.40	1.14	1.01
Netherlands	109.62	44.31	22.54	15.29	11.66	8.03	6.22	5.13	2.95	2.23	1.86
Switzerland	97.54	39.39	20.00	13.54	10.31	7.08	5.46	4.49	2.55	1.91	1.58
U.K.	-0.23	0.45	0.68	0.75	0.79	0.83	0.85	0.86	0.88	0.89	0.89
U.S.	-4.99	-1.74	-0.66	-0.30	-0.12	0.06	0.15	0.20	0.31	0.34	0.36
Mean	43.29	17.77	9.26	6.43	5.01	3.59	2.88	2.46	1.60	1.32	1.18

* Optimal hedge ratios are those that minimize portfolio risk. Negative values imply that currencies should be bought forward rather than sold forward. That is, risk is minimized when the portfolio is long more currency than that required to purchase the cross-border stock.

Table 21 Optimal Hedge Ratios for Equally-Weighted
 Cross-Border Bond Portfolios*
 (1991 Q1 - 1995 Q4, in %)

Country	Percent Invested Cross-Border										
	1	2.5	5	7.5	10	15	20	25	50	75	100
Australia	21.03	8.90	4.85	3.50	2.83	2.16	1.82	1.62	1.21	1.08	1.01
Canada	4.44	2.28	1.55	1.31	1.19	1.07	1.01	0.97	0.90	0.88	0.87
France	33.61	13.93	7.37	5.19	4.09	3.00	2.45	2.12	1.47	1.25	1.14
Germany	21.49	9.14	5.03	3.66	2.97	2.28	1.94	1.74	1.32	1.19	1.12
Italy	14.12	6.20	3.56	2.68	2.23	1.79	1.57	1.44	1.18	1.09	1.05
Japan	4.29	2.33	1.68	1.46	1.35	1.25	1.19	1.16	1.09	1.07	1.06
Netherlands	29.30	12.23	6.54	4.64	3.69	2.74	2.27	1.98	1.42	1.23	1.13
Switzerland	12.81	5.72	3.35	2.57	2.17	1.78	1.58	1.46	1.23	1.15	1.11
U.K.	-15.56	-5.45	-2.07	-0.95	-0.39	0.18	0.46	0.62	0.96	1.07	1.13
U.S.	29.14	11.99	6.28	4.37	3.42	2.47	1.99	1.71	1.14	0.95	0.85
Mean	15.47	6.73	3.81	2.84	2.36	1.87	1.63	1.48	1.19	1.10	1.05

* Optimal hedge ratios are those that minimize portfolio risk. Negative values imply that currencies should be bought forward rather than sold forward. That is, risk is minimized when the portfolio is long more currency than that required to purchase the cross-border bond.

Managerial Implications

As noted above, the role that currencies play in shaping total portfolio risk and return varies, depending on what base-currency is chosen, on what cross-border currencies are chosen, on whether investments are made in stocks or in bonds, and on the proportion of the portfolio that is invested cross-border. In managing the currency component of cross-border stock and bond investments, a portfolio manager should (1) determine the likely impact that currencies are likely to have on his portfolio's risk and return; (2) identify his overall portfolio risk and return preferences; and (3) develop a currency-hedging program that is tailored to the portfolio's own currency characteristics as well as to the manager's risk and return preferences.

Both active and passive approaches have been developed and are used by portfolio managers to hedge currency exposures. The selected approach generally reflects the management style and performance objectives of the portfolio manager.

Passive currency management usually takes one of three forms: fully hedging currency exposure at all times, never hedging currency exposure, or always hedging some preset portion of currency risk exposure. In addition to the forward contracts discussed above, currency risk and return can also be managed using futures contracts, currency swaps and currency options.

Active currency management also takes several forms. In some portfolios, currencies are viewed as a separate asset class. Decisions about how much currency exposure there should be and whether this exposure should be long or short are made more or less independently of the cross-border asset selection process.

Active currency hedgers who believe that exchange rate movements can be predicted may use a timed hedge approach. Their view is that portfolio returns

will be enhanced if currency risk is hedged only when hedge protection is needed. Technical and fundamental market timing models are often used to determine when to place and lift hedges.

Other active currency managers use options or option replication techniques to obtain protection against adverse currency moves while benefiting from favorable movements. Such approaches do not require a directional view of the market. Various analytical techniques, such as dynamic hedging, are used to rebalance hedge positions over time.

Appendix A: Algebraic Constructs

The base-currency return on a cross-border security investment for which currency risk exposure is not hedged (r_{uh}) may be defined in terms of the security's local currency return (r_{lc}) and the return on the cross-border currency (r_{fx}). That is,

$$(1+r_{uh}) = (1+r_{lc})(1+r_{fx}) \quad (1)$$

Similarly, the base-currency return on a cross-border security for which currency risk exposure is perfectly hedged with forward currency contracts (r_{ph}) is given by

$$(1+r_{rp}) = (1+r_{lc})(1+r_{prem}) \quad (2)$$

where r_{prem} is the forward currency premium.

Currency returns and forward premiums reflect the direct quote convention for currency exchange rates which measures the value of the cross-border currency in terms of the base currency. Currency return r_{fx} is defined as the percentage change in the currency's spot exchange rate over a given period. Spot exchange rates pertain to currency transactions that are priced for immediate delivery.

The forward currency premium r_{prem} is defined as the difference between the currency's spot exchange rate and forward exchange rate expressed as a percentage of the spot exchange rate. Forward exchange rates pertain to currency transactions that are priced at the beginning of the period, but which take place at the end of the period.

In order for the currency risk exposure of a cross-border security to be perfectly hedged, the end-of-period market value of the security must be known at the beginning of the period when the hedge position is established in the forward market. Since cross-border investments often have uncertain cash flows and uncertain market values at a given point in time, it is unlikely that a perfect hedge will occur in practice; that is, it is unlikely that just the right amount of cross-border currency will be sold in the forward market.

If we define X_{fwd} as the hedge ratio, or the proportion of the cross-border investment that is hedged in the forward market, the base-currency return on the cross-border security (r_b) is given by

$$r_b = r_{lc} + r_{fx} + r_{lc}r_{fx} + X_{fwd}(r_{prem} - r_{fx}) \quad (3)$$

When $X_{fwd} = 0$, that is, when the currency risk exposure is not hedged, r_b will be equivalent to r_{uh} defined Equation (1) above. That is,

$$r_b = r_{uh} = r_{lc} + r_{fx} + r_{lc}r_{fx} \quad (4)$$

When $X_{fwd} = 1 + r_{lc}$, all currency risk will be hedged away and r_b will then be equivalent to r_{ph} as defined in Equation (2) above. That is,

$$r_b = r_{ph} = r_{lc} + r_{prem} + r_{lc}r_{prem} \quad (5)$$

Since r_{lc} is generally not known at the beginning of the period when the hedge is put in place, it is unlikely that a hedge ratio equal to $1 + r_{lc}$ would be

chosen in practice.

When $X_{\text{fwd}} = 1$, that is, when an amount of cross-border currency equal to the beginning value of the cross-border investment is sold in the forward market, the base currency return becomes

$$r_b = r_{lc} + r_{\text{prem}} + r_{lc}r_{fx} \quad (6)$$

In accord with Equation (6), when the currency exposure related to the initial amount of the investment is hedged in the forward currency market, the base-currency return depends on (a) the return on the investment measured in local currency terms, (b) the forward premium return earned on the hedge, and (c) the spot currency return earned on the amount by which the ending value of the security exceeded or fell short of the hedged amount.

We can extend this analysis to include a portfolio of different cross-border securities and currencies. In this case, the overall cross-border portfolio return R_{CBP} is defined as a weighted sum of individual cross-border security returns. The weights used reflect the base currency proportions initially invested in each cross-border security.

When these weights are applied to variables r_{lc} , r_{fx} and r_{prem} we obtain overall portfolio values for security return, currency return and forward currency premium. These are denoted by R_{lc} , R_{fx} and R_{prem} respectively. Equation (3) then becomes

$$R_{\text{CBP}} = R_{lc} + R_{fx} + R_{lc}R_{fx} + X_{\text{fwd}}(R_{\text{prem}} - R_{fx}) \quad (7)$$

Our analysis can be extended further by adding to our portfolio securities

denominated in the base currency. If we let w denote the proportion of the total portfolio that is invested cross-border, total portfolio return is given by

$$R_p = (1-w)R_{CBP} + wR_{CBP} \quad (8)$$

where R_{CBP} is the return on the base currency portfolio expressed in terms of the base currency. Combining Equations (7) and (8) gives us

$$R_p = (1-w)R_{CBP} + w[R_{LC} + (1-h)R_{FX} + hR_{RREM} + R_{LC}R_{FX}] \quad (9)$$

where h is defined as the proportion of the cross-border portfolio that is hedged in the forward currency markets.

In accord with modern portfolio theory, the risk of a diversified portfolio is measured by the standard deviation of portfolio returns. Noting that the standard deviation of portfolio returns is defined as the square root of the variance of portfolio returns, we define portfolio variance in terms of random variables: R_{CBP} , R_{LC} , R_{FX} and R_{PREM} , and one cross-product variable: R_{LC*FX} .¹⁾ The variance and covariance of these variables are denoted VAR and COV respectively. Portfolio variance is given by

$$\begin{aligned} \text{VAR}_p = & (1-w)^2 \text{VAR}_{BPC} + w^2 \text{VAR}_{LC} + w^2(1-h)^2 \text{VAR}_{FX} \\ & + w^2 h^2 \text{VAR}_{PREM} + w^2 \text{VAR}_{LC*FX} + 2w(1-w) \text{COV}_{BPC,LC} \end{aligned}$$

1) Typically, the forward currency premium (RPREM) is not considered to be a random variable when the hedging horizon corresponds to the term of the forward contract. For multi-period analyses, however, forward currency prices are not known with certainty for periods subsequent to the first period. Consequently, forward currency premium should be treated as a random variable. As a practical matter, forward currency premium volatility does not contribute significantly to overall portfolio volatility.

$$\begin{aligned}
& +2w(1-w)(1-h)\text{COV}_{\text{BPC,FX}} + 2w(1-w)h\text{COV}_{\text{BPC,PREM}} \\
& +2w(1-w)\text{COV}_{\text{BPC,LC*FX}} + 2w^2(1-h)\text{COV}_{\text{LC,FX}} \\
& +2w^2h\text{COV}_{\text{LC,PREM}} + 2w^2\text{COV}_{\text{LC,LC*FX}} \\
& +2w^2(1-h)h\text{COV}_{\text{FX,PREM}} + 2w^2(1-h)\text{COV}_{\text{FX,C*FX}} \\
& +2w^2h\text{COV}_{\text{PREM,LC*FX}}
\end{aligned} \tag{10}$$

We then define portfolio volatility as the square root of variance. That is,

$$V_p = \text{VAR}_p^{1/2} \tag{11}$$

This is our measure of portfolio risk.

We can determine the risk-minimizing hedge ratio for each level of w , the proportion of the portfolio that is invested cross-border. The optimal hedge ratio h^* is found by setting the partial derivative of Equation (10) with respect to h equal to zero and then solving for h^* . That is,

$$h^* = \frac{w^2(\text{VAR}_{\text{FX}} + \text{COV}_{\text{LC,FX}} - \text{COV}_{\text{LC,PREM}} - \text{COV}_{\text{FX,PREM}} + \text{COV}_{\text{FX,LC*FX}} - \text{COV}_{\text{PREM,LC*FX}}) + w(1-w)(\text{COV}_{\text{BPC,FX}} - \text{COV}_{\text{BPC,PREM}})}{w^2(\text{VAR}_{\text{FX}} + \text{VAR}_{\text{PREM}} - 2\text{COV}_{\text{FX,PREM}})} \tag{12}$$

Similarly, given the chosen hedge ratio h , we can determine the optimal (risk-minimizing) level of cross-border investment, denoted w^* , by setting the partial derivative of Equation (10) with respect to w equal to zero and then solving for w^* . That is,

$$w^* = \frac{\text{VAR}_{\text{BPC}} - \text{COV}_{\text{BPC,LC}} - (1-h)\text{COV}_{\text{BPC,FX}} - h\text{COV}_{\text{BPC,PREM}} - \text{COV}_{\text{BPC,LC*FX}}}{\text{VAR}_{\text{BPC}} + \text{VAR}_{\text{LC}} + (1-h)^2\text{VAR}_{\text{FX}} + h^2\text{VAR}_{\text{PREM}} + \text{VAR}_{\text{LC*FX}} - 2\text{COV}_{\text{BPC,LC}} - 2(1-h)\text{COV}_{\text{BPC,FX}} - 2h\text{COV}_{\text{BPC,PREM}} - 2\text{COV}_{\text{BPC,LC*FX}} + 2(1-h)\text{COV}_{\text{LC,FX}} + 2h\text{COV}_{\text{LC,PREM}} + 2\text{COV}_{\text{LC,LC*FX}} + 2(1-h)\text{COV}_{\text{FX,PREM}} + 2(1-h)\text{COV}_{\text{FX,LC*FX}} + 2h\text{COV}_{\text{PREM,LC*FX}}} \quad (13)$$

Joint optimization of h and w can be accomplished by applying the Kuhn-Tucker theorem. As a practical matter, optimal values for h and w can be obtained using a numerical approach whereby h and w are allowed to vary incrementally between 0 and 1 (inclusive.) Portfolio risk is calculated for each pair of h and w ; optimal h and w values are those for which portfolio risk is minimized.

A more general optimization can be achieved by using a generalized optimization model in which the decision variables represent the proportions of both hedged and unhedged cross-border stocks and bonds as well as base currency stocks and bonds. An even more generalized approach would be to view stock and bond returns in local currency terms and to include currencies as an asset class. In this case, the proportions of currency spot or forward to buy or sell would be decision variables as would base currency and cross-border stock and bond proportions.

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